ISOLDE EURISOL R&D FOR ISOL FACILITIES

H. L. Ravn, the ISOLDE and the EURISOL Collaboration

1. INTRODUCTION TO EUROPEAN RIB FACILITIES AND NETWORKS

After recommendation of NuPECC the collaboration on European Isotope Separation On-Line Radioactive Nuclear Beam Facility (EURISOL) has just finished a study [EUR03] of a major European RIB facilty.
The described facility is intended to extend and amplify, beyond 2010, the exciting work presently being carried out using the first-generation European ISOL-RIB facilities by raising the RIB beam intensities by a factor of 1000 beyond the limits of presently available facilities.
This 2-year study has thoroughly investigated the scientific and technical challenges posed by such a facility, identified the R&D required before a full engineering design-study can be undertaken, and establish a cost-estimate of capital investment and running costs. The improved research capabilities described in the study by the Key Experiments Task Group is planned to be obtained by a combination of the innovative developments listed within the following fields:

Driver Accelerators
Target & Ion Sources
Post-Accelerators & Mass Spectrometers
Instrumentation for experiments

Synergies with other European installations and projects has also been identified and a number of joint research networks on key technologies have been formed as well as a Engineering Design Study group. Their funding is planned to be obtained from the traditional national funding schemes as well as from the upcoming European Commission's 6th PCRD.

Below a short description of the EURISOL project in relation to the near future of the European RIB facilities is given followed by a more detailed description of the R&D on key technologies presently being planned to be done by a number of new or existing networks within the above mentioned fields. Finally its relevance to RIA and opportunities for international collaborations are discussed.

2. EURISOL AND EXISTING EUROPEAN RIB-FACILITIES

The EURISOL study report describes a major site independent ISOL-RIB facility complementary to the already existing projectile fragmentation RIB facilities at GSI and GANIL in which future European RIB research may be regrouped. Its technology, R&D and organization is based on the large number of low energy on-line mass separator RIB facilities that have been or are in operation in Europe. They have now been followed by the three operating accelerator driven ISOL-RIB-facilities at ARENAS Louvain La Neuve [ARE03], REX-ISOLDE [ISO03] and SPIRAL-

GANIL [SPI03]. In addition the reactor driven MAFF facility at Munich [MAF03] and the accelerator driven EXCYT at Catania [EXC03] are presently under construction and the new projects SPES [SPE03] is in the planning phase at Legnaro.
The EURISOL baseline scenario describes a 1-GeV, 5-MW CW proton LINAC driven facility, with a possible upgrade to 2 GeV. It has multiple target stations for driver beam power up to 100kW of absorbed power in directly irradiated targets and one for 1MW of absorbed power in a spallation neutron source indirectly driving a fission target. Via an innovative switchyard the low energy beams may be distributed to high resolution mass separators, low energy experimental areas, bunching and charge-breeding devices followed by one or several LINAC post accelerators.
The obvious alternatives such as cyclotrons and heavy ion and deuteron driver particles are also discussed.
Access to RIB will in the near future be assured by the facilities operating or under construction mentioned above and possibly followed by various upgrade schemes. R&D within the EURISOL collaboration may therefore put its emphasis on developments that consolidates and improves the techniques in the four fields mentioned in section 1 so that it can be immediately applied and tested in the operating facilities in order to assure optimal use in the future high-intensity EURISOL. Other aspects like developments of LINACs and MW targetry the EURISOL may support as a minor partner in their already existing networks.

3. R&D TOPICS PLANNED FOR DRIVER ACCELERATOR

The EURISOL base-line driver accelerator, a 1-GeV, 5-MW CW proton facility, with a possible upgrade to 2 GeV, has remarkable synergies in components and R&D needs with other high-intensity projects. The proposed solution is thus in the mainstream of today's accelerator development.
The demonstration of the injector accelerator, up to about 10 MeV, relies on existing projects like IPHI or the TRASCO injector. Therefore, EURISOL supports that full funding for these R&D projects is continued.
Two items have high R&D priority: (a) construction of complete prototype accelerator sections for low-β elliptical SCRF cavities; (b) development of prototypical spoke, quarter-wave and re-entrant cavities with associated auxiliary RF components, to be tested with beam from existing facilities.
Assuming that it is possible to establish common R&D programmes with other projects, it should be investigated whether common designs could be adopted.

4. R&D TOPICS PLANNED FOR THE TARGET & ION SOURCE

In view of the fact that Europe in the near future will have 3 to 6 mostly new ISOL-RIB facilities the EURISOL R&D work on the targets and ion sources will be concentrated on developments that immediately can be exploited and validated by the running facilities and less on the MW power converter target described in the EURISOL report [TIS03]. Below the key points of these developments presently being persued by a nomber of R&D networks and a Design Study are commented while more details are found in Table 1.

General target developments

The purpose of these studies is to optimise and validate the existing target and ion techniques for 1GeV proton beam intensities in the range of 10-100μA and and improve the mass transfer efficiency via the following main points:

Optimised release from ISOL targets TARGISOL [TAR03]
Develop beams that are not available
Improvements of beam emittance and purity
Improved life time of the target and ion source units
Optimisation of targets driven by neutrons from proton to neutron converter
Determination of fundamental design parameters from operating targets

Resonant Ionization laser ion source development

The Resonance Ionisation Laser Ion Source (RILIS), [JRA09] is the most promising ion source for ISOL-RIB facilities. It has a large potential that wil be addressed in the following R&D program:

1. Improve the efficiency and development of new laser systems for RILIS
2. Improve the selectivity
3. Improve the accuracy of the in-source spectroscopy
4. Study the feasibility to produce polarised beams of exotic nuclei using RFQ-coolers and laser-induced polarization
5. Produce pure ground-state and isomeric beams of exotic nuclei and establish the in-source laser spectroscopy of short-lived nuclei
6. Accumulate, cool, bunch and polarize radioactive ion beams.
7. Reduce the delay time
8. Optimize the temporal structure of the beam

Network on ECR and EBIS charge breeding

In contrast to the first charge breeding project, where the principle of charge breeding has been proved with stable and radioactive isotopes, the objective of the proposed project is the optimization of the charge breeding process itself, e.g. the breeding efficiency, the beam quality and the beam preparation before injection into the accelerator with a separator set-up.
The main objectives of the project [JRA03] are:

1. To narrow the charge state distribution by manipulation methods to obtain the highest efficiency in a single charge state

2. To optimize the purification of very weak beams (e.g. 100 fA of radioactive ions) and rather intense beams (e.g. 10 μA) from rest gas contamination in the same separator. Comparison of breeding measurements with both charge state breeders.

3. To optimize the transverse and longitudinal emittance of the extracted beams, using cooling techniques in the beam preparation and in the ion sources.

Safety and Handling

Originating from the drastically increased radioactive inventory of upgraded existing or newly built Europan radioactive beam facilities, the following list of tasks has been

has been proposed to be addressed in a EU network on safety and radioactivity handling (SAFERIB), [JRA11] in order to ensure safe operation also for next-generation high-intensity RIB facilities.

1. Characterization of radiation at/from production target: production rates of radionuclides
2. Characterization of radioactive inventory in target area/beam transport system
3. Characterization of mechanical, thermal and radiation-correlated material properties for production targets/fission sources and handling devices
4. Optimization of radiation shielding by simulation calculations and dosimetry measurements
5. Study on migration of radioactivity with emphasis on production, dispersion and release of alpha emitters
6. Containment of gaseous radioactivity
7. Development of failsafe remote controlled target and ion source unit manipulators
8. Technical solutions for a contamination-free transport, diagnostics and storage of used targets/sources
9. Safety studies on potential risk and failure scenarios (including impact on aintenance personnel and environment)

Target for use with a 4MW 1-2 GeV proton beam

No EURISOL-ISOLDE program exists on targetry for the 4 MW proton beam. It is planned that EURISOL-ISOLDE will participate in the Advanced Design Validation and Innovative Concepts for the Next European Neutron Source (ADVICES) [ADV03] by using the ISOLDE target area for studying thermal shock waves in solid or liquid targets neutron production.

ISTC network on Proton accelerator based intense source of radioactive ions for nuclear physics experiments

The proposed project [ISTC03] is aimed at the design and development of a radioactive ion source combined with a rotating disc proton to neutron converter made of ^{13}C, B_4C planned to be used with a proton beam at an energy of up to 100 MeV in the framework of the collaboration between INP and LNL for the SPES project.

5. R&D TOPICS PLANNED FOR POST-ACCELERATOR & MASS SPECTROMETER

1. Study and construction of a test facility to establish the feasibility of the proposed TOF mass-separator.
2. Developments and improvement of the RF-cooler technique.
3. Continuation of developments on SC cavities, in order to reduce the cost of the superconducting linac and to increase its performances as much as possible.

6. R&D TOPICS PLANNED FOR INSTUMENTATION TASK

1. Ion and atom traps improvements and new applications
2. Polarised radioactive beams and special targets.
3. Gamma-ray tracking
4. Signal analysis and aplication-specific electronics Development of application-specific integrated circuits (ASICs) for nuclear physics

5. Charge and mass identification through pulse-shape analysis
6. Study off separators and spectrometers for EURISOL.
7. Electronics and data acquisition systems for nuclear physics,

7. RELEVANCE TO RIA AND SUGGESTIONS TO INTERNATIONAL COLLABORATION

REFERENCES

[ADV03] Advanced Design Validation and Innovative Concepts for the Next European Neutron Source (ADVICES)
[ARE03] LNL-INFN (REP) 145/99
[EUR03] EURISOL http://www.ganil.fr/eurisol/index.html
[EXC03] http://web2.lns.infn.it/celona/
[ISO03] http://isolde.web.cern.ch/ISOLDE/
[ISTC03] logatchev@inp.nsk.su
[JRA03] EU network on charge breeding http://www.ha.physik.uni-muenchen.de/okester/rexisolde.html
[JRA09] Resonant Ionization laser ion source development JRA_09_LASER
[JRA11] JRA_11_SAFERIB
[MAF03] http://www.ha.physik.uni-muenchen.de/maff/
[SPE03] http://www.lnl.infn.it/spes/introspes.pdf.
[SPI03] http://www.ganil.fr
[TAR03] http://www.targisol.csic.es/
[TIS03] http://www.ganil.fr/eurisol/Final_Report/C-TIS-report-1-August-2003.pdf